Energy recovery during the braking operation

Dipl.-HTL-Ing. Reinhard Kapeller
Manager Application Marketing
14-15 SEPTEMBER 2011, MUNICH
Energy recovery during the braking operation

● List of used abbreviations
  ● BU       Braking unit
  ● BR       Braking resistor
  ● AFE      Active Front End
  ● A/C      Air condition unit
  ● PCC      Point of common coupling
  ● ATV61    Frequency inverter type ATV61
  ● ATV71    Frequency inverter type ATV71
  ● ATV61Plus Customizable inverter cubical with ATV61
  ● ATV71Plus Customizable inverter cubical with ATV71
  ● n        Speed
  ● T        Torque
  ● P        Power
  ● I        Current
  ● J        Inertia
Application – Sugar centrifuge

Recoverable energy due to:

- angular kinetic energy \( W_{\text{rot}} = \frac{J \times \omega^2}{2} \)

Energy (Power × time)
Application – Sugar centrifuge

Input data:
- Inertia with wet product: 350 kgm²
- Inertia with dry product: 280 kgm²
- Nominal speed of centrifuge: 1900 rpm
- Nominal speed of motor: 1500 rpm
- Inertia of motor and pulleys: 5.2 kgm²
- Ramp up / down time: 35 s
- Total efficiency: 0.88
- Typical cycle time: 250 s
- Cycles / hour: 10
- Operation time / day: 24 h
- Days / year: 350 d
- Energy cost: 0.13 €/kWh
- Energy CO2 content: 300 g/kWh

Energy calculation:
- Gearbox ratio: 0.83
- Total inertia: 408.4 kgm²
- Angular speed: 157.1 rad/s
- Rot energy: 5038433 J (Ws)
- Rot energy: 1.40 kWh
- Braking energy / cycle: -1.2 kWh
- Braking energy / day: -295.6 kWh
- Braking energy / year: -103456 kWh
- Yearly saved cost: 13449 €
- Yearly reduced CO2: 52 t
Application – Hoist

Recoverable energy due to:

- potential energy \( W_{\text{pot}} = m \times g \times h \)

Energy (Power \( \times \) time)
Application – Hoist

Input data:
- load weight: 63 t
- weight hook: 12 t
- speed: 13 m/min
- total efficiency: 0.88
- typical lifting height: 14 m
- typical cycle time: 10 min
- operating hours / day: 24 h
- working days / year: 350 d
- energy cost: 0.09 €/kWh
- Energy CO2 content: 500.00 g/kWh

Energy calculation:
- ideal power: 159 kW
- lift power: 181 kW
- descent power: -140 kW
- time to lift/decent: 54.5 s
- lifting: 11705 kWs
- decent: -9064 kWs
- Energy / cycle: -25179 kWh
- Energy /day: -362,5776 kWh
- Energy /year: -126902 kWh
- yearly saved cost: 11421 €
- yearly reduced CO2: 63 t
Application – Decline conveyor

Recoverable energy due to:

- potential energy $W_{pot} = m \times g \times h$

Energy (Power $\times$ time)
Application – Decline conveyor

Input data:
- length: 1250 m
- load capacity: 500 t/h
- speed: 100 m/min
- elevation: -133 m
- friction on belt: 43000 N
- total efficiency: 0.9
- operation time/day: 16 h
- days/year: 250 d
- energy cost: 0.09 €/kWh
- Energy CO2 content: 500,00 g/kWh

Energy calculation:
- angle: -6.11°
- time: 750,00 s
- actual tonnage: 104 t
- force: -108728 N
- power on load: -181 kW
- total force: -65728 N
- power on shaft: -110 kW
- electric recovered power: -99 kW
- yearly saved energy: -438183,3 kWh
- yearly saved cost: 39436,5 €
- yearly reduced CO2: 219 t
Braking Solutions

Schneider Electric offers 2 different braking options

**Braking Unit**

- VW3A7101 Braking Unit with external braking resistor in IP21

**Active Front End**

- AFE - Active Front End consisting of LFM / LFC / AIC
Braking Unit with Braking Resistor

BU/BR converts recovered energy to heat (losses)
Available up to 200kW continuously / 900kW peak
Enhanced power rating with parallel connection possible
Active Front End

**V, I**

$P_{motor} = \sqrt{3} \times U \times I \times \cos \varphi$

**V, I**

$P_{generator} = \sqrt{3} \times U \times I \times (-\cos \varphi)$

AFE … feeds recovered energy back to mains with a THDi < 4%

Available up to 850kW continuously, Enhanced power rating with parallel connection possible
Active Front End
Active Front End

AFE orderable as single components
- LFM … Line Filter Module
- LFC … Line Filter Choke
- AIC … Active Infeed Converter

AFE in ATV61/71 Plus version
(customizable cabinet solution)
- IP 23, IP54, separated air flow …
Decision guidance BU / AFE

● Payback period

● Calculation of recoverable energy (per cycle, hour, day, year) → ___ kWh

● Determine the yearly saved costs (saved energy * energy cost) → ___ €

● Determine costs for braking unit, braking resistor, mounting and harmonic mitigation → ___ €

● Determine costs for Active Front End, mounting → ___ €

● Payback period = (AFE costs – BU/BR costs) / yearly saved cost → ___ years
Decision guidance  BU / AFE

● Further points that have to be considered
  ● Available mounting space in electric room for BU/BR or AFE
  ● Handling of emitted heat from braking resistor
    - additional A/C needed?
    - IP rating?
    - EX zone?
    - distance between BU and BR?
  ● Are some THDi limits requested? (harmonic mitigation)
    BU/BR solution … passive or active filter, multipulse solution
    AFE … THDi < 4% without any further measure
  ● Energy feedback in power grid is often undesired, recovered energy
    should be used in own environment (before PCC)
  ● Energy feedback on generator supply needs other consumers as a basic
    load
  ● Reduction of CO₂ emission due to energy saving
System configuration “4Q Drive”

Decline conveyor

1 AFE + 1 Drive
System configuration “DC bus”

1 AFE + 3 Drives
- hoist
- long travel
- trolley

Crane application
System configuration “DC bus”

1 AFE + 2 Drives
- centrifuge 1
- centrifuge 2

Sugar centrifuge
System configuration “DC bus”

Tube profiling line

2 AFE + 60 pcs. ATV’s
System configuration “DC bus”

- Basic dimensioning for DC Bus
  - Calculation of total power under consideration of motor and drive efficiency, dynamic load situations (emergency stop), equalization of motor and generator load and utilization factor
  - Value of capacitors switched on DC bus (prevent LFM overload during precharging phase)
  - Total length of motor cables (RFI measures)
  - Total length of DC bus structure
  - Max 4 pcs. AFE in parallel
  - Only ATV61/71 drives on DC Bus allowed

System configuration
“Low Harmonic Drive”

Water treatment pump

Diagram showing the system configuration with AFE (Active Front End) and INV (Inverter). The diagram illustrates the flow of power with and without the AFE, showing a significant decrease in Total Harmonic Distortion (THD) from 35% to 4%.

Current with AFE (THD < 4%)
Current without AFE (THD 35%)
Conclusion

Find optimal braking solution for your application under consideration of:

- Functionality
- Energy efficiency
- Mounting / Installing
- Harmonic mitigation

For any further help or information please get in contact with your local Schneider partner!
NOW!
You know!